

MIDTERM EXAMINATION 1

Directions: Do all 3 problems, which have unequal weight. This is a closed-book closed-note exam except for one $8\frac{1}{2} \times 11$ inch sheet containing any information you wish on both sides. A photocopy of the four inside covers of Griffiths is included with the exam. Calculators are not needed, but you may use one if you wish. Laptops and palmtops should be turned off. Use a bluebook. Do not use scratch paper – otherwise you risk losing part credit. Cross out rather than erase any work that you wish the grader to ignore. Justify what you do. Express your answer in terms of the quantities specified in the problem. Box or circle your answer.

Problem 1. (45 points)

A surface charge of uniform density σ_0 Coul/m² is glued onto a spherical shell of radius R that is centered at the origin.

(a) (10 points)

Relative to ∞ , find the potential V_0 at the origin.

(b) (5 points)

How much work W was done to move the charge from ∞ to the shell?

(c) (10 points)

The shell is now split along its “equator” into two hemispheres, and the south hemisphere is thrown away. Find the new potential $V_{1/2}$ at the origin.

(d) (20 points)

For the conditions of part (c), calculate the potential V_N at the “north pole” $(0, 0, R)$.

Problem 2. (25 points)

A point charge q is held at a distance z above an infinite conducting plane that is grounded ($V = 0$). Calculate the surface charge density σ_s on the plane at a distance $s \gg z$ from the charge. Accuracy to lowest nonvanishing order in z/s is sufficient.

Problem 3. (30 points)

A thin phonograph record is composed of a material that has a uniform volume charge density; the total charge is Q . The record has radius R and rotates on a turntable at angular velocity $\vec{\omega}$. Calculate the magnetic field at the center of the record.